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HIGH-SPEED WIND-TUNNEL TESTS OF GUN OPENINGS

IN THE NOSE OF THE FUSELAGE OF

A 1/4-SCALE MODEL

By Henry A. Fedziuk

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**NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS**

**ADVANCE CONFIDENTIAL REPORT**

**HIGH-SPEED WIND-TUNNEL TESTS OF GUN OPENINGS**

**IN THE NOSE OF THE FUSELAGE OF**

**A 1/4-SCALE MODEL**

**By Henry A. Fedziuk**

**SUMMARY**

In connection with recent tests of a 1/4-scale model pursuit airplane in the NACA 8-foot high-speed tunnel, gun openings having low drag were developed for installation in the nose of the fuselage. The increase in the fuselage-drag coefficient for the final form of openings was 0.0132 at a Mach number of 0.69 and at an angle of attack of 0°. The corresponding drag coefficient based on the wing area was about 0.0005. The critical speed of the airplane was not affected by the gun openings.

**INTRODUCTION**

One of the difficulties encountered in the design of an advance pursuit airplane is the determination of the proper shape of gun opening in the nose of the fuselage. The openings should be of such design that they add the smallest possible amount of drag and do not lower the critical speed of the airplane.

A portion of the testing program of an advance pursuit-type airplane in the NACA 8-foot high-speed tunnel at Langley Memorial Aeronautical Laboratory was allotted to develop openings with these features. The drag was measured at speeds as high as the critical speed of the basic airplane.

**APPARATUS**

The tests were made of openings on a 1/4-scale model pursuit airplane in the NACA 8-foot high-speed tunnel. Four .50-caliber machine guns and four 20-millimeter.

cannons were located in the nose of the fuselage. Two of the machine-gun openings and two of the cannon openings were placed, one inboard and one outboard, on each side of the nose of the fuselage. The outboard gun openings were tested with and without hoods. When the outboard openings were covered by hoods, the hoods were cut from a body of revolution and fastened to the fuselage. (See figs. 1, 2, and 3.) The nose ordinates for the hoods are the ordinates for nose A presented in reference 1, table II, under the heading  $d/D = 0.536$  where  $d/D$  is the ratio of the inlet diameter to the maximum fuselage diameter and is used as a parameter in the test described in reference 1. Nose A is shown nondimensionally in figure 20 of reference 1. In order to adapt the nose A ordinates to the hoods,  $X$  (shown in fig. 20 of reference 1) was taken as 1 inch and  $Y$  was assumed to be  $1/2$  inch. From the 1-inch station rearward the profile of the hood was faired into the fuselage.

### TEST PROCEDURE AND RESULTS

Preliminary force tests of single openings were made to determine the effect of faired openings and hoods on the drag. The effect on lift and pitching-moment coefficients was also noted during the tests. The drag increments were found by taking the difference between force-test measurements of the drag of the basic wing-fuselage combination with and without the gun openings. Although the differences are small in this case, the data are sufficiently accurate to show the amount of drag caused by the gun openings. Fuselage-drag increments  $\Delta C_{Df}$  are based on free-stream dynamic pressure and the maximum fuselage cross-sectional area, which is equal to 0.75 square foot. No peak-pressure measurements were made during the tests, but the force-test measurements were used to determine the effect of the openings on the critical speed of the airplane.

The test Mach-number range extended from about 0.18 to 0.69 and the angle of attack  $\alpha$  of the fuselage, which was the same as the angle of attack of the wing, was varied from  $3^\circ$  to  $-3^\circ$ .

Test of single outboard .50-caliber machine-gun opening.- The outboard .50-caliber machine-gun opening was tested without a hood for different values of the local radius along the intersection of the gun opening and the fuselage. In the first test, no attempt was made to fair the intersection

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(shown as dashed outline in one view of fig. 1); in the second test, modification 1, the sharp edge of the opening was rounded with the radius along the intersection varied from 1/32 inch to 3/16 inch (fig. 1); and in the third test, modification 2, the value of the local radius along the intersection was twice the value of the radius for modification 1. Varying the local radius did not change the drag of the opening. In the plot (fig. 4) of drag increments for the outboard gun-opening test, one curve, therefore, represents the increase in drag coefficient for all three conditions of the gun opening.

The same opening was then tested with a hood. In this test the original opening was changed to a circular opening when the designers of the airplane changed the method of setting the elevation of the guns and it was found unnecessary to have as large an opening as the original opening. The increase in fuselage-drag coefficient caused by the circular opening with the gun hood is shown in figure 4.

The openings were located in a favorable pressure gradient and a laminar boundary layer existed over the forward portion of the nose. The natural transition location on the fuselage was behind the openings. The flow was turbulent, however, just behind the opening, with the result that a part of the drag increase shown in figure 4 is due to a change in the type of flow and the rest of the drag increase is due to the shape of the opening. The transition point on the full-scale airplane is farther forward than on the model used in the tests and it is probable that the values of drag increment found, although small, are conservative. Thus, for an outboard single-gun installation the increase in drag at full scale is likely to be negligible.

#### Test of single inboard .50-caliber machine-gun opening.-

The inboard .50-caliber machine-gun opening was tested in the same way as the outboard gun opening, except that for the inboard opening the local radius along the intersection was varied in modification 1 from 1/16 inch to 3/32 inch. In this test, as for the outboard opening, the increase in drag was the same for all conditions of the opening and is represented by the solid curve when the drag increments are plotted (fig. 5).

The original outline of the opening was changed to a circular opening and the drag increment caused by a circular opening is shown as a dashed line in figure 5. Changing

to a circular opening decreased the drag increment as compared to the drag of the original opening.

The tests of the original and the circular, the faired and the unfaired, inboard openings were made with natural transition. Transition was then fixed behind the inboard opening by a strip of No. 60 carborundum grains glued to the surface of the fuselage about 15 inches from the nose. The drag increments for the circular opening with fixed transition are shown in figure 5. Part of the drag increment for this opening would be caused by the formation of a turbulent boundary layer, as described previously for the outboard opening, and the drag increment for the full-scale airplane would probably be smaller than for the model used in the tests because the transition point is located farther forward at full scale.

Figure 6 shows the same results as figures 4 and 5, but includes also the drag increments for angles of attack of  $1.5^\circ$  and  $-1.5^\circ$ .

Test of complete gun installation.— The final tests were made of the model with the complete gun installation including four .50-caliber machine-gun openings and four 20-millimeter cannon openings. The outboard openings were hooded and the transition point was fixed just behind the rearward gun hood as shown in figure 1. The drag increments for this arrangement of the openings are shown in figure 7. At a Mach number of 0.69 and at an angle of attack of  $0^\circ$ , the increase in fuselage-drag coefficient is equal to 0.0132 which corresponds to a drag coefficient, based on the wing area, of about 0.0005.

The force-test measurements indicate that the openings had no effect on the critical speed of the airplane. The lift and pitching-moment coefficients were not affected to any appreciable extent.

## CONCLUSIONS

1. Eight gun openings installed in the nose of the fuselage increased the fuselage-drag coefficient by 0.0132 at a Mach number of 0.69 and at an angle of attack of  $0^\circ$ . The corresponding drag increment, based on the wing area, is approximately 0.0005.

2. The eight gun openings had no effect on the critical speed of the airplane.

Langley Memorial Aeronautical Laboratory  
National Advisory Committee for Aeronautics  
Langley Field, Va.

#### REFERENCE

1. Becker, John V.: Wind-Tunnel Tests of Air Inlet and Outlet Openings on a Streamline Body. NACA A.C.R., Nov. 1940.

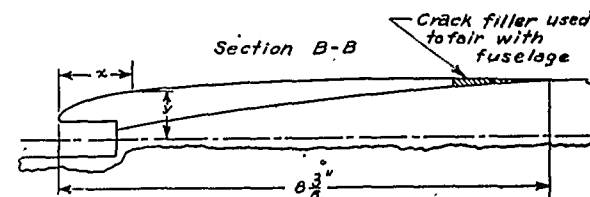
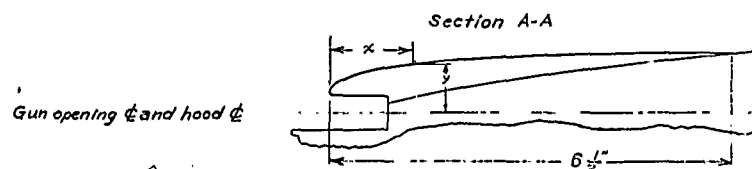
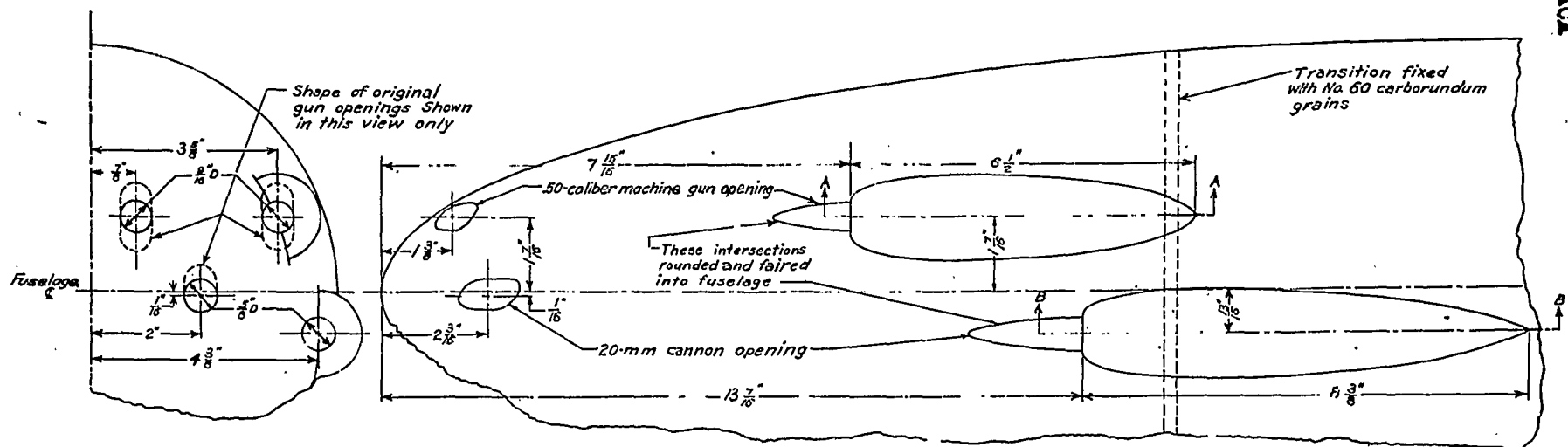


Figure 1—Gun installations on  $\frac{1}{4}$ -scale model pursuit airplane as tested in NACA 8-foot high-speed tunnel.

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Hood ordinates (in.)	
x	y
0	0.300
.01	.344
.03	.377
.075	.432
.15	.499
.30	.582
.50	.651
.80	.732
1.00	.781
1.50	.830
2.00	.880
2.50	.900
3.00	.930
4.00	.970
5.00	.980
6.50	.990

Hoods made circular in cross section

Scale  $\frac{1}{4}$ " = 1"

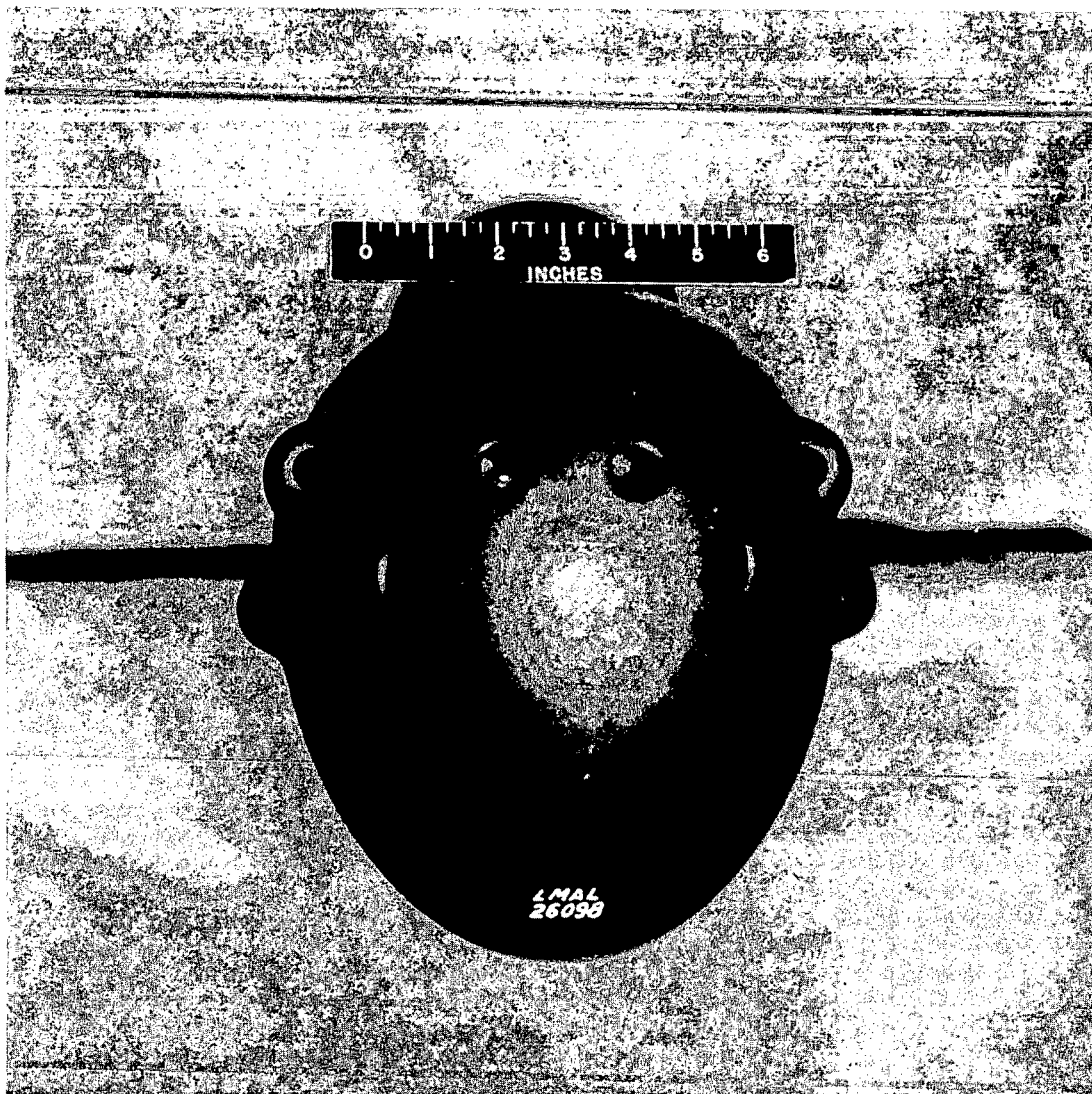


Figure 2. - Front view of nose of fuselage model showing positions of openings for complete gun installation.



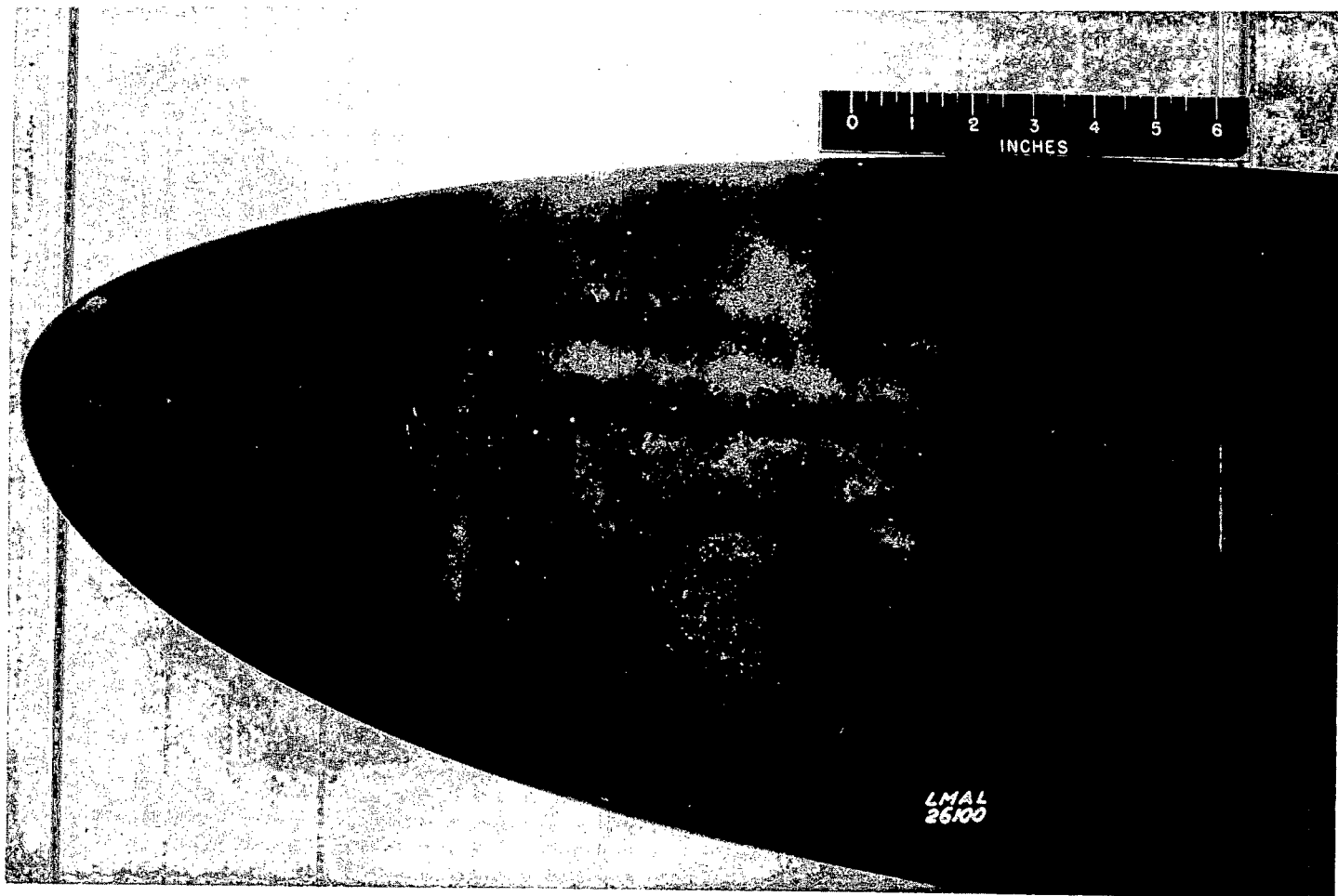


Figure 3. - Side view of nose of fuselage model showing positions of inboard and outboard openings.

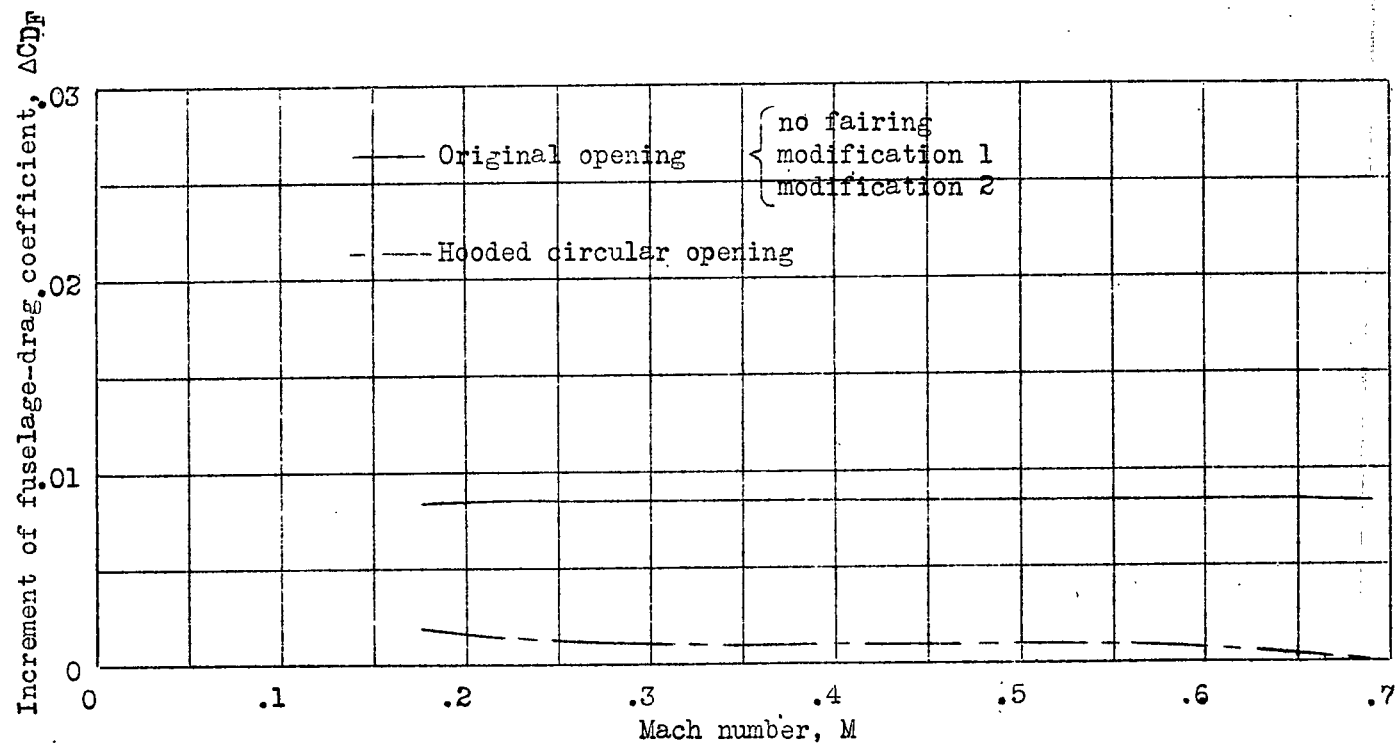


Figure 4.- Increment of fuselage-drag coefficient,  $\Delta C_{D_F}$ , based on maximum fuselage cross-sectional area due to an outboard .50-caliber machine-gun opening in the nose of the fuselage of a 1/4-scale model airplane. Natural transition;  $\alpha = 0^\circ$ .

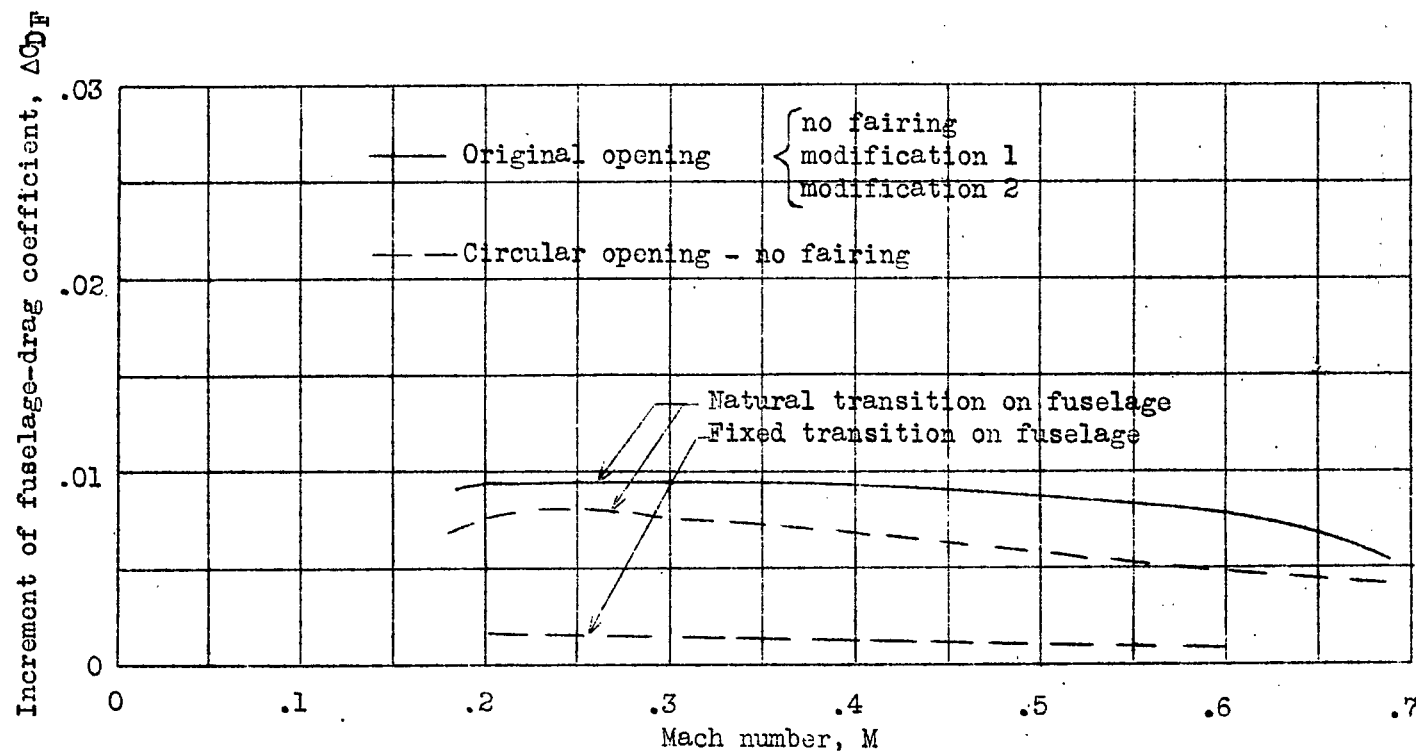


Figure 5.- Increment of fuselage-drag coefficient,  $\Delta C_{DF}$ , based on maximum fuselage cross-sectional area due to an inboard .50-caliber machine-gun opening in the nose of the fuselage of a 1/4-scale model airplane. Natural transition;  $\alpha = 0^\circ$ .

— Original outboard opening  
 - - - " inboard "  
 - - - Circular " "  
 - - - " hooded outboard opening

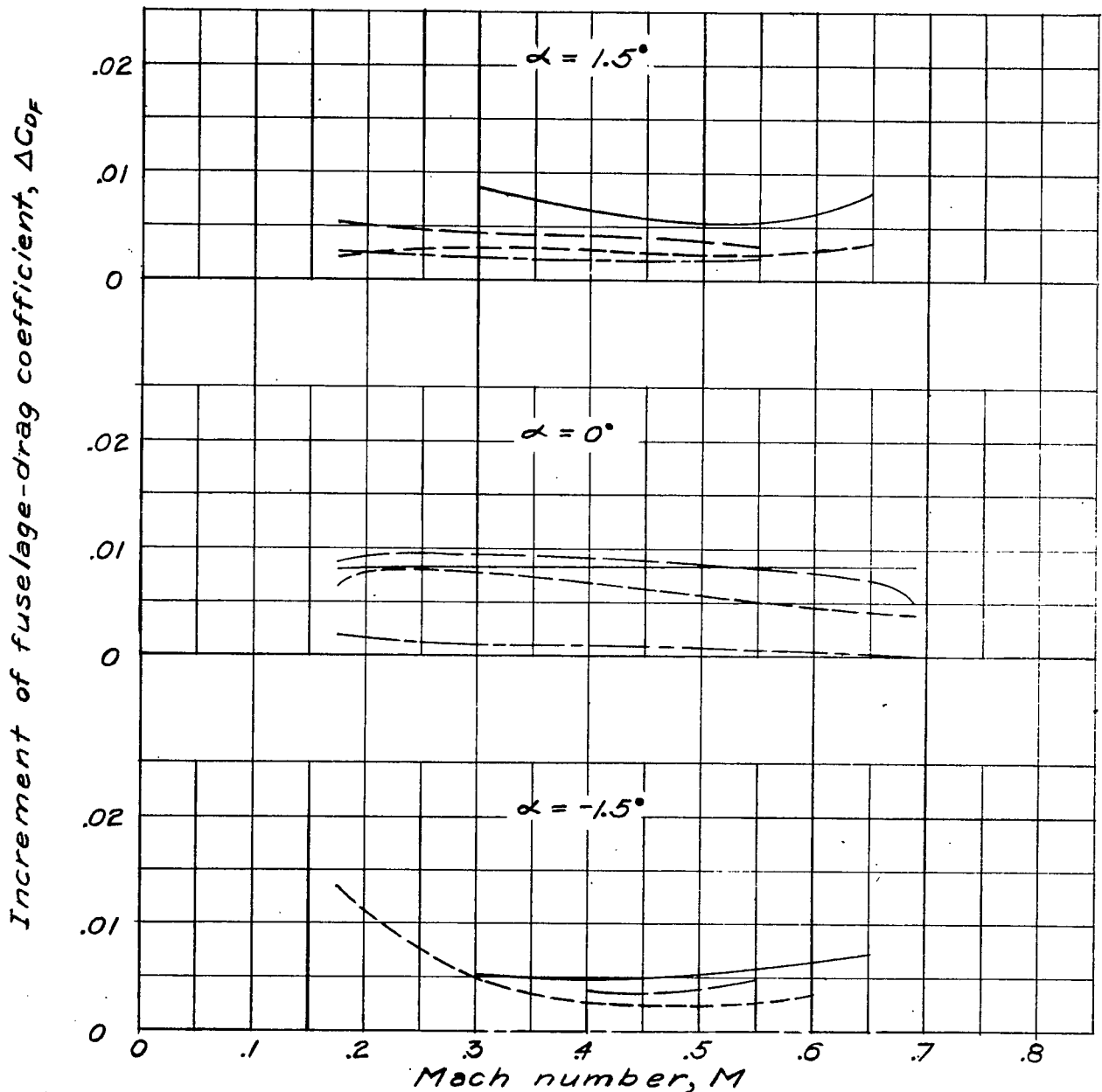


Figure 6.-Increment of fuselage-drag coefficient,  $\Delta C_{DF}$ , based on maximum fuselage cross-sectional area due to an inboard and outboard .50 caliber machine-gun opening in the nose of the fuselage of a 1/4-scale model airplane. Natural transition.

— 8 Circular openings  $\left\{ \begin{array}{l} 2 \text{ inboard } .50 \text{ cal. m.g.} \\ 2 \text{ outboard " " " } \\ 2 \text{ " 20 mm cannon} \\ 2 \text{ inboard " " " } \end{array} \right\} \text{hooded.}$

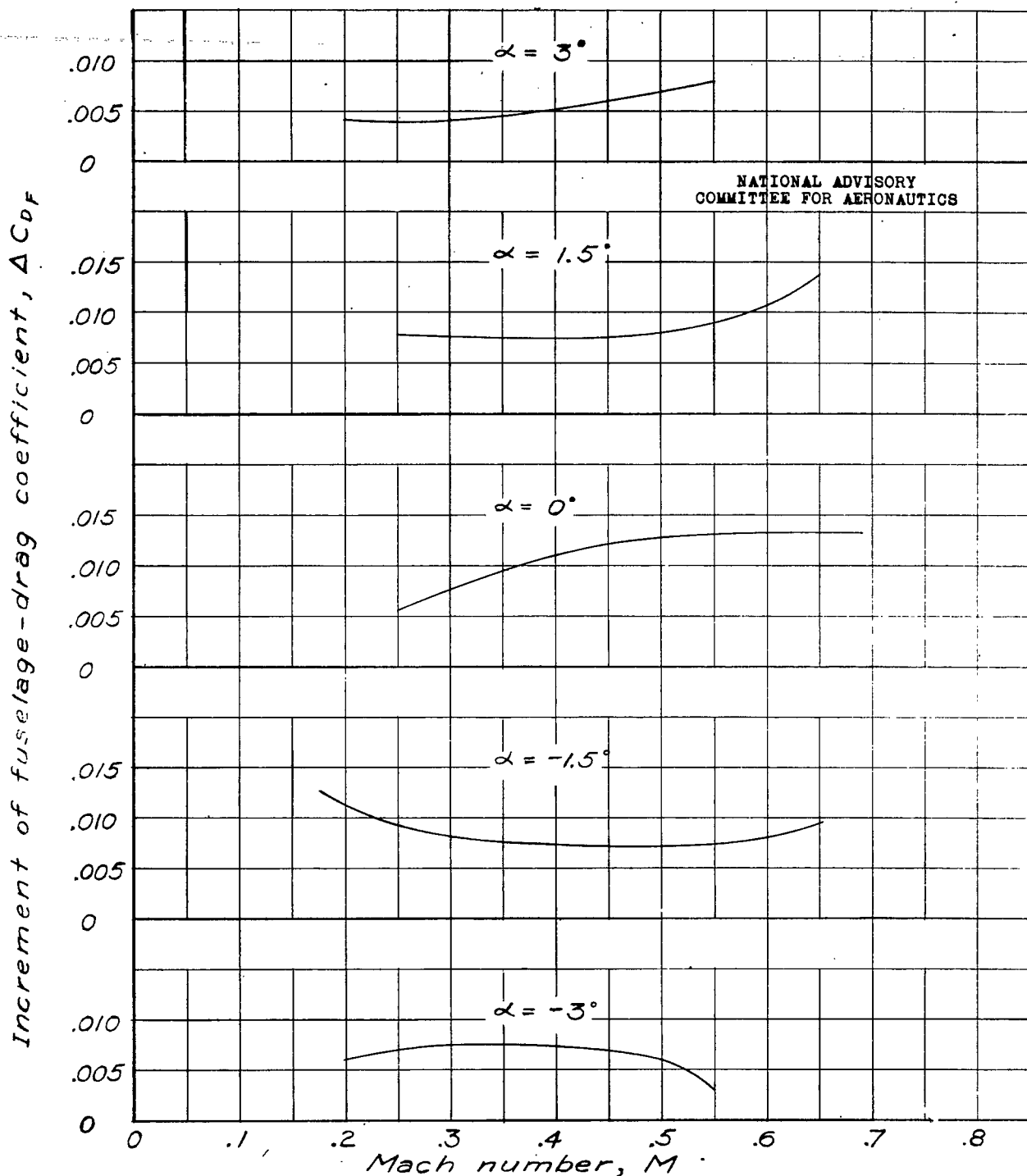


Figure 7.-Increment of fuselage-drag coefficient,  $\Delta C_{Df}$ , based on maximum fuselage cross-sectional area due to eight gun openings in the nose of the fuselage of a  $1/4$ -scale model airplane. Fixed transition 15 inches from nose.

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